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# BARCO LYNX: DIGITAL OPTICAL SOLUTION FOR IF TRANSPORT OF TELEVISION SIGNALS

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Also see Appln PD 1


## 1. ABSTRACT

The cable industry has always been faced with the problem of interconnecting headends. Several modern solutions, using analog intensity modulated lasers, have proven to offer a reliable solution for short distances (10 to 30 km).

Today, however, a solution for the transport of analog signals over ring networks (covering hundreds of km thereby replacing headends by reception nodes) is a strong requirement of the cable operator who is faced with the convergence of cable and telecom operations.

Analog television signals are complex, hence digital transmission of video, audio and other signals (teletext) requires extensive signal processing in transmission and reception nodes. It is therefore recommended to originate the TV signals only once, using high quality equipment, and then transporting it over the network while maintaining the original signal quality.

The LYNX system provides a complete solution to transmit 16 TV signals over one wavelength, offering a constant quality over the complete network, drop insert capabilities in all the reception nodes, and providing standard management and monitoring capabilities.

Although the system is targeted towards ring networks, remote program feed capabilities are offered to insert programs from a remote location.

LYNX is a synchronous system using 3.1 Gbit/s data rate and proprietary data formatting. The clock signals are processed in each reception node. This offers the possibility to have more than 100 reception nodes receiving non-deteriorating quality signals.


## 2. INTRODUCTION

The introduction of HFC networks has forced the cable industry to adapt a 3 layer network approach. The primary distribution to implement a distributed headend structure, a secundary distribution using analog signal transport and a tertiary distribution on a coaxial network. Primary and secundary distribution is done via fiber, tertiary via coax. ( Fig 1)

BARCO's supertrunk system, called LYNX, is targeted towards primary distribution of high priority signals. Primary signals can be categorized in an number of areas: analog AM VSB TV signals, FM audio signals and digitally modulated carriers. These categories cover most of the must-carry services on a cable network.

Each signal category has different requirements. In this article, a realistic scenario is used to obtain the requirements for the distribution equipment.

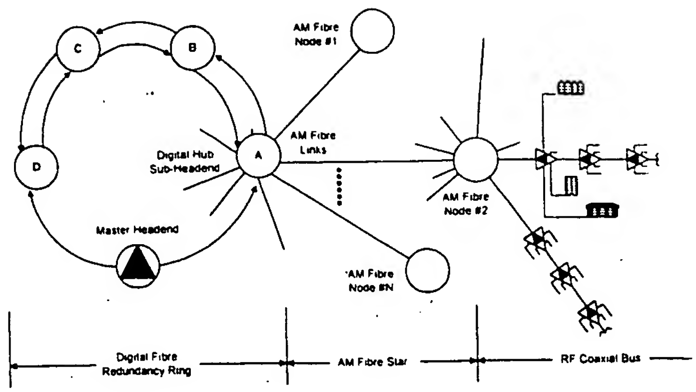


Fig 1 : Network layers

## 3. THE PRIMARY DISTRIBUTION

The structure most appropriate to build a primary structure is a ring structure. The distributed headend network has a high quality master headend and several satellite headends on the optical ring. The signal quality on the ring is determined by the quality in the master headend. Having a constant signal quality over the ring is the first requirement to be able to plan a complex network. If each satellite headend would have a different quality level, then network planning would become very difficult.

To obtain a simple topology, signals should not be broken down into components. Meaning that if an IF signal is composed out of vision, sound and additional carriers, it should be transported in that format.

A second requirement of a primary distribution system is the add/drop capability. The multiplexing system must be simple enough to allow for cost-effective add/drop functionality.

Redundancy is a third requirement. Without this, a network is not accepted for primary distribution.

Management and monitoring is also very important. The operator needs to have an overview of the network performance.

The satellite headends can each have a different topology. The concept has to allow different configurations. There has to be support for the programs that are not originated in the satellite headends. If for instance a TV studio is located 10 km away from the ring network, a remote insert solution has to be provided.

Due to the fact that bandwidth should not be a limiting factor, optical solutions are most appropriate. Fig 2 gives an overview of a network that fulfils all above requirements.

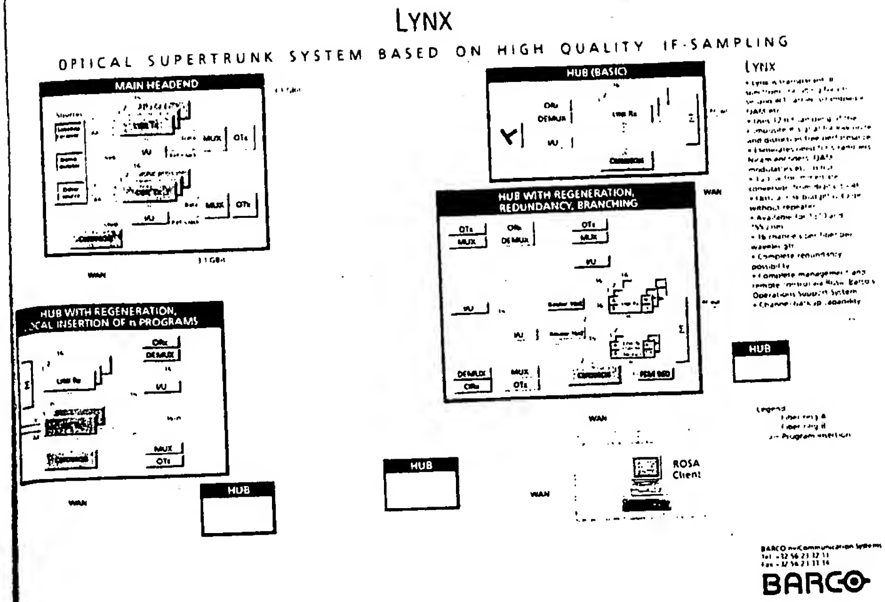


Fig 2 : Lynx concept

## 3.1. Transmission technique

The requirement of having a constant quality throughout the complete network rules out any analog transmission technique. Analog transmission can only guarantee a point to point transmission quality. The LYNX system is targeted to cover distances of hundreds of km and more than 100 reception nodes. TDM (Time Division Multiplexing) is the most straightforward technique: the use of bandwidth is acceptable and multiplexing can be handled using standard components. LYNX uses a 3.1 Gbit/s datastream, carrying sixteen 194 Mbit/s channels. The standard telecom bitrates of 155 Mbit/s do not allow the transport of IF signals because they cannot cope with IF bandwidths at the desired quality level (12 bit sampling).

The performance requirements are very elaborate. Given the fact that primary distribution has to be degradation-free, great care has been taken to avoid impairments. The lineair and non-lineair distortion has to be minimized. Each of the signal categories has its specific demands. Requirements and measured values are presented in chapter 4 of this article.

## 3.2. System Components

The LYNX system consists of 5 components. These following components are all 19" one rack unit.

- 3.1 Gbit/s multiplexers to multiplex sixteen 194 Mbit/s datastreams in one 3.1 Gbit/s and to convert this signal to an optical signal.
- 3.1 Gbit/s demultiplexers to convert the optical signal to an electrical 3.1 Gbit/s signal and to demultiplex this signal to sixteen 194 Mbit/s signals.
- LYNX Transmitters
- LYNX Receivers
- Interface units to reconstruct the clock and to perform data splitting in each reception node.
- LYNX 16*2 router to offer full automatic receiver backup.

## 3.3. LYNX Transmitters and Receivers

### 3.3.1. AM VSB TV

The bandwidth requirements differ for the different standards. The next table gives an overview of the required bandwidth.

| SYSTEM | IF 0.5 dB Range (MHz) |
|---|---|
| BG | 32.85-40.15 |
| DK 38 MHz | 31.45-38.75 |
| DK 38.9 MHz | 32.35-39.65 |
| MN | 40.95-46.65 |

To add a program on a ring, a LYNX TRANSMITTER is used (Fig 3). In the case of video and audio availability, a basic LYNX transmitter unit can be used, consisting of a high quality video/audio to IF modulator and an A/D convertor. The modulator allows for interfacing with various baseband signals, video, audio, audio intercarrier, BTSC baseband or intercarrier etc.

However, in case there is an IF signal available, a LYNX DUAL IF ENCODER can be used (Fig 4) This unit contains two A/D boards in one rack.

Error protection : in optical transmission, single bit errors can occur, whereas bursts or multi-bit errors are unlikely to happen. For high quality transmission used in CATV trunks, error protection is needed. In the LYNX system, a single-error detect and correct scheme is implemented, based on Hamming codes. Quasi free error transmission is hereby guaranteed. Making use of the detection capability, a rudimentary BER measurement can by achieved, also available to the network management.

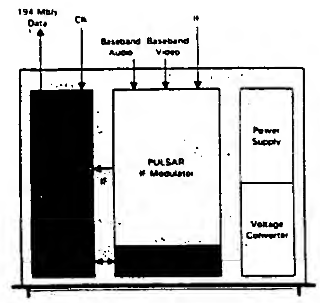


Fig 3 : LYNX ENCODER

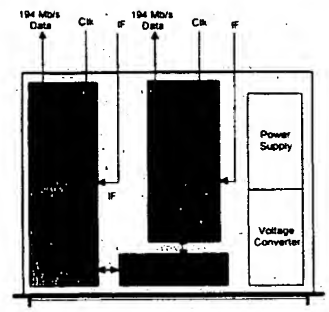


Fig 4 : LYNX DUAL IF ENCODER

To take a program from the ring a LYNX DECODER is used. This receiver accepts two 194 Mb/s data streams and clock signals from two optical receivers. The selected input is constantly monitored for errors. When a failure occurs, LYNX automatically activates the alternate input. After digital filtering and conversion, a perfectly reconstructed analog IF signal is fed to an IF to RF converter. The microprocessor-controlled converter provides an output signal at high RF level for easy combining. Thanks to its built-in intelligence, all of the important parameters such as RF level, input selection, output frequency, etc., can be remotely controlled.

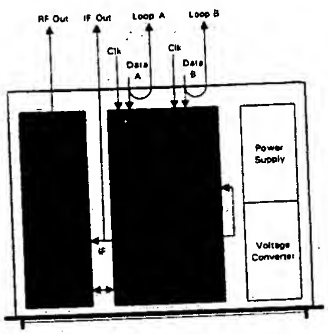


Fig 5 : LYNX DECODER

### 3.3.2. FM Programs

Audio signals are carried on a cable network using FM modulation. The bandwidth of these carriers is small compared to AM VSB signals. Occupying one 194 Mbit/s slot for each FM program is not feasible. Therefore, the FM carriers are demodulated and the multiplex signals are then transported over the ring. One 194 Mbit/s slot can contain 64 FM programs when the MPX signal is sampled. Eight MPX signals are added using one rack. By daisy chaining eight racks, 64 MPX signals can be handled.

The MPX signals are received in the satellite headends in groups of eight. Each MPX signal in a group can be replaced by another. This technique offers a high flexibility to the operator.

### 3.3.3. Digitally modulated carriers

The bandwidth for digital carriers can be near to the 8 MHz channel bandwidth. This results in a severe filtering characteristic. To keep the distortion of the signals low, special filtering techniques are used.

To add a digitally modulated signal on the ring when the digital baseband signal is available, a LYNX QAM Encoder is used. This unit consists of a digital modulator and an A/D convertor.

### 3.3.4. The interface unit

The LYNX IU is used to guarantee a multi-hub transport keeping the generation of jitter within normal limits. When cascading multiple optical links, jitter is accumulated throughout the different links. The LYNX IU is used to clean up jitter accumulation. A second function is the generation of very pure clock signals to be used by LYNX TX and RX for sampling and restoring the analog signals. Any impurity on the clock signals degenerates the quality of the restored signals resulting in decreasing SNR, spurious carriers, ....

## 4. LYNX PERFORMANCE

### *4.1. Carrier to noise for AM VSB applications*

The relation of the Carrier to Noise ratio of AM VSB signals can be calculated as following.

The Signal to Noise ratio of an ideal AD convertor is : SNR= 6.02*N +1.76 dB with N the number of bits. The noise is quantization noise equally distributed in the Nyquist bandwidth: 0 to fs/2 with fs the sampling frequency.

The sampling of an IF signal is no ideal situation:

- Next to the vision carrier, one or two sound carriers at -10 or -13 and -20 dB are present. In order to prevent overflow of the ADC, the peak Vision Carrier has to be 3 dB lower than the maximum input level of the ADC.

- Another 2 dB margin has to be taken to be able to cope with rapid signal strength variation that cannot be intercepted by the AGC circuits..

The ADC is not ideal:

- the effective number of bits (ENOB) is lower than N. A typical 12 bit ADC has an ENOB of 10.6.
- The quantization noise is equally spread between 0 and fs/2. The system does not use the total bandwidth but only 80 %. This gives a gain of 1 dB.

Conclusion : using a 12 bit ADC results in a C/N of:

C/N=6.02*10.6+1.76-5+1=61.5 dB.

Remark: a 10 bit ADC would result in a C/N value that is too low for the performance level required for primary distribution.

## 4.2. Measurement results

Description setup : for the field trial, 5 different programs were transported over 5 optical segments, each 42 km (28 miles) long . All optical devices worked in the 1310 nm window. The 5 LYNX transmitters provided in total 10 digital streams, carrying 5 different programs (a LYNX TX has an identical double output)

The errors of the measurement equipment are not compensated. It can be seen that the results are corresponding with the back to back performance of the measurement equipment.

For the NICAM signals a BARCO NE728 nicam encoder was used. Modulation of the programs (video, audio and combination of NICAM) is done with the internal analog modulator of the LYNX TX.

- Video SNR, unweighted, 5 MHz LPF, tilt null (signal = shallow ramp)

with NICAM, mono audio carrier < -51.6 dB

without NICAM, with mono audio carrier modulated : < -51.7 dB

The minor difference is due to the fact that NICAM occupies some of the spectral energy from the total IF spectrum, thereby lowering the signal strength.

- BER on NICAM

A BER of 10E-8 was achieved, after 37 min (further measurement needes 3 h for 10E-9 and 6 h for 10E-10 and was not performed). Eyeheight : 84 %

- Spurs at IF In band : spurs < -67 dB under VC Out band : spurs < -65 dB under VC
- Spurs at RF (freq 48.25 Mhz)

All Spurs < -67 dB under VC

- Spurs at RF (freq. 76.25 Mhz)

All spurs < -70 dB under VC.

- Spurs op RF (freq. 189.25 Mhz)

All spurs < -70 dB under VC

- BER measurement optical link (210 km)

After 6 h, a BER of 10E-12 was achieved (at LYNX RX).

- Teletext eyeheight

For this measurement the teletext of program 5 was used.

| | Eyeheight | ½ Eyeheight | Amplitude |
|---|---|---|---|
| Source | 87 % | 43 % | 92 % |
| After transmission | 83 % | 41 % | 95 % |

- Video parameters (PAL) : done throughout the full 5 segment link. Video inserted at LYNX TX, demodulated after LYNX RX, measurements done with Rohde & Schwarz UAF.

| **PAL video measurements** | **UAF results** | **specifications (within %)** |
|---|---|---|
| Luminance bar amplitude (rel. to 0.7V) | -0.2 % | ± 2 % |
| Base line distortion | 0.6 % | ± 2 % |
| Luminance bar tilt | 0.6 % | ± 2 % |
| 2T amplitude | 1.6 % | ± 3 % |
| Line time non linearity | 1 % | ± 2 % |
| Color subcarrier on CCIR 331 signal | 1.5 % | ± 5 % |
| Color subcarrier on 20T signal | 0.2 % | ± 5 % |
| Intermodulation on CCIR 331 signal | 0 % | ± 2 % |
| Intermodulation on 20T signal | -0.6 % | ± 2 % |
| Chrominance luminance delay | 24 ns | ± 25 ns |
| Residual picture carrier | 10.6 % | 10 % ± 1.5 % |
| Differential gain (peak-peak, 5 steps) | 0.6 % | ≤ 2 % |
| Differential phase (peak-peak, 5 steps) | 0.6 dg | ≤ 2 dg |
| Sync pulse amplitude (rel. to bar amplitude) | -2.7 % | ± 3 % |
| Burst amplitude (rel. to bar amplitude) | 3.4 % | ± 5 % |

## 5. NETWORK MANAGEMENT

BARCO's ROSA system is a powerful, and well-accepted tool for headend monitoring. It gives an overview of the network, reports alarms in an intuitive fashion and supplies easy access to device configuration. Fault management is handled through the ROSA user interfaces. ROSA provides graphical visualization of quality of service. The system also includes features for monitoring some parts of the distribution plant.

In those cases where a general Operations Support System is planned or deployed, the elements will appear via (proxy) SNMP agents on the OSS. An additional (software only) package is being developed which can process the telemetry from all the various surveyed network elements and provide an "expert opinion" on the causes, impacts and suggested recovery procedures.

The goal of integration of ROSA into total network management systems is to provide a single solution which helps to ensure end to end reliability, predicts and thereby prevents outages, and provides the operations and facilities management necessary to operating and maintaining HFC plant.

As CATV and Telecommunication networks are being integrated, open interfaces are mandatory. For this reason, BARCO is making a clear separation between the element management system (Copernicus) and the ROSA CATV network management software. The Copernicus server can communicate with both ROSA and other network management systems simultaneously.

### *5.1. The ROSA Client-Server System*

In this version, the ROSA software is split into two parts : the server software running on the Copernicus element manager and the client software running on a 32 bit Windows platform (Windows 95 for ROSA 1.5; Windows 95 or Windows NT for ROSA 2.0).

The Copernicus element manager will maintain an object model for each controlled device. This object model can communicate with the ROSA clients as well as with other management systems through the SNMP interface.

The Copernicus Element Manager communicates with the Network Management System by means of a data communication network (TCP/IP protocol).

### *5.2. COPERNICUS Tasks*

- support client / server access for multiple clients of different types (currently ROSA or SNMP).
- headend or distribution node automation : some tasks that normally have to be done manually are performed automatically by the element manager.
    - automatic backup of defective devices
    - automatic adjustment of the RF output levels for all channels
    - proactive performance analyses
- offer a high level device-independent model of the services received and provided by the headend or distribution node. By providing this service level model of the managed installation, the interface to the supervising management system becomes device-independent. This interface will therefore be stable for a long time.
- acquisition of quality of service data
- provide an object model for all attached devices (BARCO and non-BARCO devices)
- alarm correlation and filtering
- support user defined tasks
- offer a generic interface to a video/audio matrix router. The [illegible] router can be used by the [illegible] backup system, a performance monitoring system and by the [illegible] (at a remote location)

### 5.3. ROSA Tasks

The main tasks of the ROSA system (and other Operations Support Systems) is to provide a user interface for visualizing and controlling the information stored on the Copernicus system :

- fault management :
  - alarm logs
  - visualization of devices and services
- configuration management :
  - device configuration parameters
  - network structure / configuration
  - service configuration
- performance management :
  - quality of service alarm threshold definitions
  - quality of service logs
- security / protection system

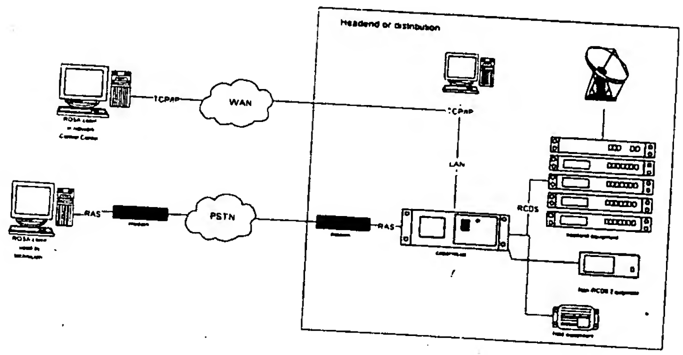


Fig 6 : ROSA/Copernicus

## 6. CONCLUSION

The LYNX concept provides a unique distributed headend philosophy, ensuring constant quality transport over the entire network, regardless the number of reception nodes fed. Analog equipment, digital equipment, fiber optics and software are all interacting and provide a way to reach a secure backbone or primary distribution network for present and future cablecom operators.